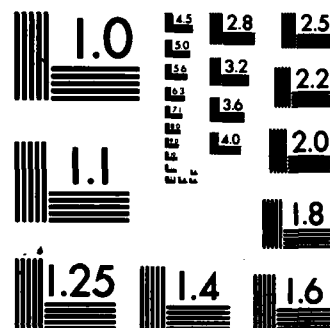


AD-A140 008 ON THE STABILITY OF FLIGHT VEHICLES IN THE LOW REYNOLDS 1/1  
NUMBER NON-LINEAR. (U) MASSACHUSETTS INST OF TECH  
CAMBRIDGE GAS TURBINE AND PLASMA D. E E COVERT ET AL.  
UNCLASSIFIED FEB 84 N00014-82-K-0310 F/G 20/4 NL





MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

AD A140008

GAS TURBINE AND PLASMA DYNAMICS LABORATORY  
DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
CAMBRIDGE, MA 02139

A FINAL REPORT

on

ONR CONTRACT NO: N00014-82-K-0310

entitled

ON THE STABILITY OF  
FLIGHT VEHICLES IN THE LOW REYNOLDS  
NUMBER NON-LINEAR REGIME

prepared for

Department of the Navy  
Office of Naval Research, Code 432F  
800 North Quincy Street  
Arlington, VA 22217  
Attn: Dr. Robert Whitehead  
Head, Fluid Mechanics Division

AUTHORS:

E. E. Covert  
Director, Gas Turbine & Plasma Dynamics Lab  
Professor of Aeronautics & Astronautics

Otto W. K. Lee  
Graduate Research Assistant  
Department of Aeronautics & Astronautics

Carol M. Vaczy  
Graduate Research Assistant  
Department of Aeronautics & Astronautics

February 1984

APR 10 1984  
A

This document has been approved  
for public release and sale; its  
distribution is unlimited.

DTIC FILE COPY

84 02 21 008

The work reported herein was carried out on this grant during its active life, that is from September 1981 to September 1983. The primary effort may be divided, for the purpose of this discussion, into three parts. The first part consists of a literature survey in external fluid mechanics, (i.e., flow over wings and bodies) in the Reynolds number range of 20,000 to 200,000.<sup>1</sup> This work was summarized at (the ONR-Supervised Workshop on: Low Reynolds Numbers Flow) in February 1983. The second part was a technical review of the material presented at ~~that~~ <sup>^</sup>workshop.<sup>2</sup> The third ~~and last~~ part was a trajectory study for a vehicle flying in the low Reynolds number regime.<sup>3</sup> The trajectory study was initiated as a means of accessing the stability of a vehicle flying under circumstances where (a) the aerodynamic characteristics are non-linear and (b) there is coupling between lateral motion (which can induce local stalling) and pitching motion. It is found that for the case studied a modified form of the Liapunov Stability Criteria using a phase-plane, provided a suitable description of the motion. The unstable lateral motion of the vehicle chosen for analysis is shown, ~~in figure 1.~~ The instability is indicated by steady growth of the curve away from any particular point shown on the plane. This work is incomplete in that time did not permit study of reverse interesting features; like the effect of lift curves hysteresis on the motion.

Copies of references 1 and 3 are enclosed herewith.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
<i>Attache</i>	
at attention/	
Availability Codes	
Avail and/or	
Special	
A-1	



## REFERENCES

- (1) "Low Speed Aerodynamics in The Reynolds Number Range of 20,000 to 200,000," MIT Aero Dept. Report by E. E. Covert and M. Drela, Feb. 1983.
- (2) Letter from E. E. Covert to Dr. Dean Mook, Fluid Dynamics Group/ Code 432, ONR dated Feb. 9, 1983.
- (3) "On the Stability of Flight Vehicles in the Low Reynolds Number Non-Linear Regime," MIT Aero Dept Report by Otto W. K. Lee, Carol Vaczy and Eugene E. Covert, Jan. 1984.

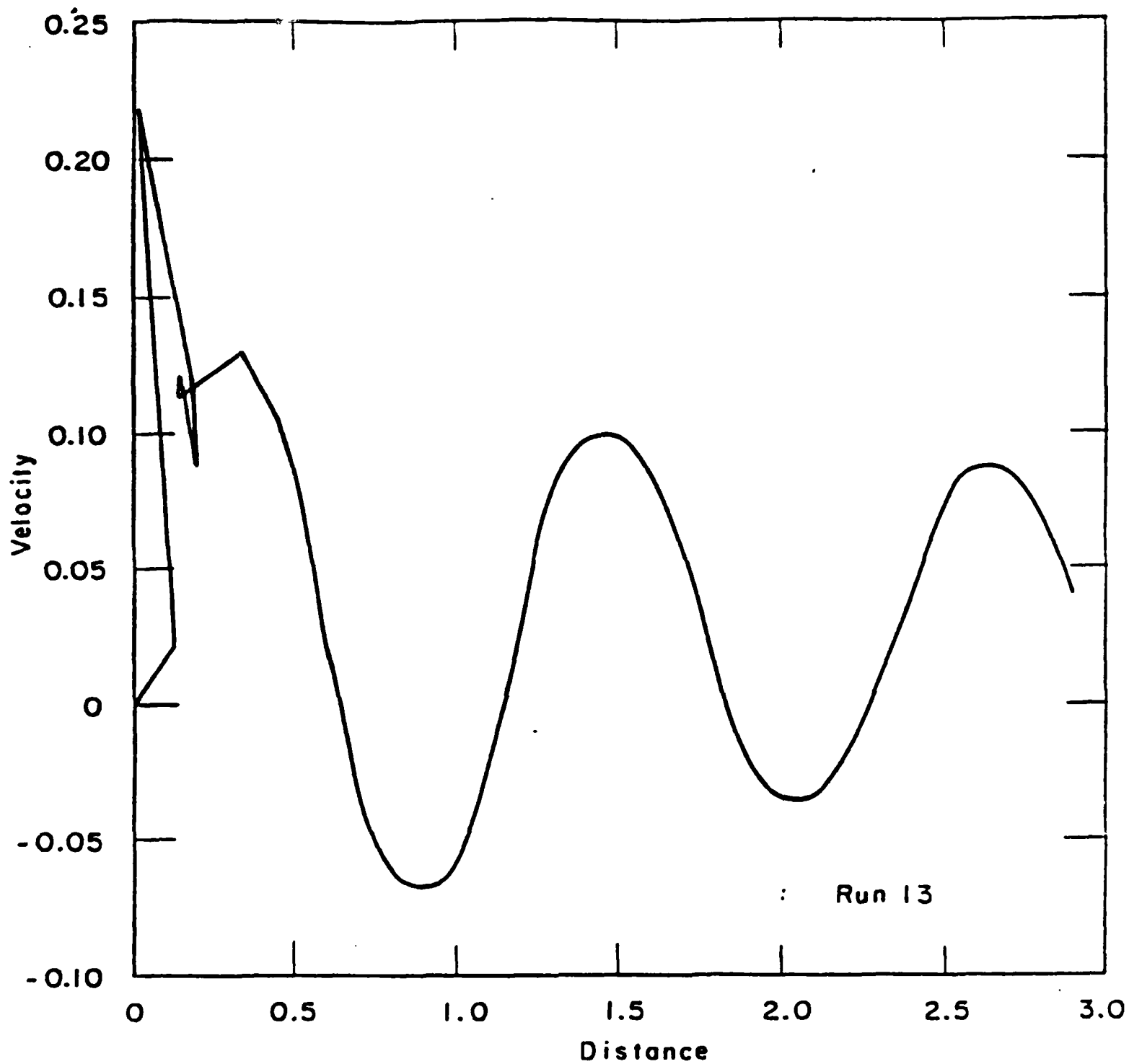


FIG. 1

LIAPUNOV STABILITY

 $C_L = 2.33$ 

INITIAL OFF SET 2° YAW

END

FILMED

6-84

DTIC